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THE AMERICAN

METEOROLOGICAL JOURNAL.

VOL. XI. BOSTON, MASS., FEBRUARY, 1895. No. 10.

THE CAUSE OF THE CYCLONES OF THE TEMPERATE LATITUDES.

W. H. DINES, F. R. MET. SOC.

THE problem of the formation and maintenance of the cyclones of our latitudes is one of the most interesting subjects of meteorology, and it is one on which considerable difference of opinion exists.

It is not so very long since that we did not know that the winter gales, that sometimes occur so frequently, are parts of large eddies of the atmosphere moving bodily over land and sea, generally towards the east or northeast. The introduction of weather maps has, however, rendered the character of these cyclones clear to most of us, and has also explained the cause of the central barometric depression produced by the centrifugal action of the eddying winds, but the immediate cause of the eddies themselves is still uncertain.

Two theories have found considerable support: one, the convection theory, commonly known as Ferrel's, not because it was first suggested by him, but because he so fully explained and worked it up; the other, proposed, I believe, by Dr. Hann, and sometimes known by his name.

Until a few years ago a belief in Ferrel's theory as the cause of our storms seemed to be gaining ground. It is still thought by most of those who have studied the subject that convection plays the chief part in the production of the sub-tropical hurricanes, but some observations on the temperature in cyclones and anticyclones, made at high stations in the Alps, and brought forward by Dr. Hann, have led to the idea that convection currents have not much influence in the formation of the storms of the temperate latitudes.

Personally, I believe the weight of evidence to be decidedly in favor of Ferrel's, or the convection theory, and I propose to mention briefly some of the points which are relied upon by those who uphold either side of the question.

Ferrel's theory has been explained by himself in his "Popular Treatise on the Winds." An account is also given in Prof. Davis's "Elementary Meteorology," in which as little mathematics as possible is employed. Stating it briefly, Ferrel supposed that the cyclones were caused by the convectional ascent of a current of warm air in the central parts, the heat necessary to sustain the current being supplied, at least in part, by the latent heat set free by the condensation of aqueous vapor.

Unfortunately, the upward current has been likened to the current of warm air up a chimney, but the simile is not a good one, and has led to much misconception. Such a current would certainly give rise to a most torrential rainfall, and may, perhaps, occur in thunderstorms and tornadoes; but a study of the velocity of the winds, and the average inclination of their direction to the isobars, show that in an ordinary cyclonic storm the velocity of the upward motion of the air is only some few hundred feet per hour, a rate utterly insignificant when compared with the horizontal motion. For a full understanding of Ferrel's theory an acquaintance with the elementary laws of mechanics and thermodynamics is necessary; it is in strict accordance with these laws, and it may be confidently asserted that it is at least a possible theory.

Dr. Hann considers that the storms are merely eddies formed in the general easterly drift of the atmosphere in the temperate latitudes, just as small whirls are formed in a river; but so far as I am aware no one has explained how or why these whirls are formed.

Ferrel's theory requires a supply of warm, moist air, and a rapid decrease of the temperature as we ascend, since these are the conditions requisite for an unstable condition of the air, and the inevitable formation of convection currents. The convection current being formed, it is plain that it cannot be maintained unless the air is warmer in the parts where it is rising, that is, in the central parts of the cyclone, than it is at places in the surrounding districts at approximately the same altitude.

The test is not whether the air is warmer or cooler at exactly

the same altitude, but at heights at which there is exactly the same pressure.

The two most important points quoted in opposition to the theory seem to be, firstly, that cyclones are most prevalent in the winter, whereas they should be least prevalent, because then the temperature gradient decreases most slowly as we ascend; secondly, because Dr. Hann has found that the temperature at high mountain stations in the Alps is higher during anticyclonic conditions than during the passage of storms.

With reference to the first statement, is it so very certain that the temperature gradient is less in winter? At continental stations, no doubt, it is, but at such stations the necessary aqueous vapor is often lacking in the summer. Over the North Atlantic, a favorite breeding ground for these storms, the mean summer temperature is hardly 15° Fahr. above the winter, owing to the high specific heat of water and the circulation from the tropics; and it seems reasonable to suppose that the upper layers of air vary from winter to summer by at least 15° Fahr., if not more. The mean temperature of the north temperate zone varies more than 15° Fahr., and it is probable that the upper air taken over the whole zone has on the average the same amount of variation. If this be so, then the winter temperature gradient is equal to, or greater than, the summer one, and although at the lower temperature of the winter months the air does not hold so much moisture, and hence there is less chance of the latent heat being so efficacious, still the objection in great measure falls to the ground. However this may be, the rainfall gives us an absolutely exact measure of the latent heat set free in any considerable time; and over the coasts of the North Atlantic, and doubtless also over the ocean, the rainfall is greater in winter than in summer. But even if the temperature gradient is less in winter than in summer, there is another cause which may more than compensate for this. The cyclones may be considered as secondaries occurring in connection with the main cyclonic circulation round the poles, and since this circulation is stronger in the winter, the secondaries formed in it are also likely to be stronger.

The second objection is based on the temperatures at mountain stations. In the Alps there is no doubt that, during the winter months, the upper layers of air are warmest during anti-

cyclonic conditions. According to Dr. Hann, the temperature is from 6° to 10° Fahr. higher. A very important correction must, however, be applied to this. The air, in passing from a region of high pressure to one of low, will expand, and cool in virtue of its expansion, and in so far as this cooling is concerned, it is brought about just as much by a change of position from an anticyclone to a cyclone, as by a change of altitude. In England the change of pressure may roughly be taken as one inch of mercury, since cyclones in which the barometer falls below 29.25 in. are very common, and this difference of pressure, viz., one inch, will produce an adiabatic cooling of about 5° Fahr. After applying this correction, the temperature test, as it is supplied by high level stations in the Alps, does not seem to me to be very conclusive.

But there are other objections that are sometimes made. The Alps lie out of the common track of the cyclones, and it has been stated that other mountain stations more favorably situated do not show the same result. Again, can we be sure that the observed mountain temperature fairly represents that of the free air at the same level? In windy, cyclonic weather, it probably does so; but in the calm, clear weather, which characterizes such stations during anticyclonic conditions, may not the mountain itself influence the temperature? The snow slopes of the mountain are cooled by radiation, the air in contact with them is cooled and sinks into the valleys, its place being supplied by air from above. Thus the general downward tendency which prevails over the whole anticyclonic area is greatly intensified close to the peak, and since in general, and more particularly in the dry, cloudless air of an anticyclone, a descending current of air is so warmed by compression that its temperature rises, and it becomes essentially a warm current, the temperature at the summit of the mountain will be unduly high.

There is another way of looking at Dr. Hann's facts as to temperature. They show that in cyclonic conditions of weather the temperature decreases rapidly as we ascend, and this is the exact condition that Ferrel's theory requires in the places which the cyclone is just approaching.

Passing now to the points which tell in favor of Ferrel's theory, the first, in my opinion, is the fact that cyclones show a decided preference for tracks where there is a copious supply of

moist air. Thus, in America, they pass over the Great Lakes and down the St. Lawrence valley. In Western Europe they mostly skirt the Irish, Scotch, and Norwegian coasts, where the warmth and moisture requisite for the convection current is supplied by the Gulf Stream, and if they do pass over the land their energy is greatly lessened before they have travelled far. If Dr. Hann's theory be correct, why should these storms be rare over the continent of Europe, but of almost daily occurrence on the Western coast of Scotland? The absence of friction over the sea may explain their greater violence, but not their greater frequency, for if they originate in the upper current, there can be no reason why they should favor one kind of surface more than another. The friction of the land surface can only reduce the velocity of the surface winds; it cannot alter the number of cyclones in a given time, or have more than a trifling effect upon the barometric gradient.

Again, if these storms are eddies produced in the upper current, surely they ought to be most frequent on the lee or eastern side of high mountain ranges. This would give a maximum over the plains of North America, and a minimum over the Southern ocean, whereas the latter locality is perpetually swept by these storms both summer and winter.

The experimental evidence on the matter is not worth much, for it is impossible to imitate the conditions which are introduced by the deflective force of the earth's rotation; also, the motion of a small mass of liquid does not allow us to draw conclusions about the motion of a film of air a few miles thick, but a thousand or more miles across. Likewise, a strict mathematical investigation is out of the question, and would be, even if we might treat the air as a perfect fluid, and neglect friction altogether. Mathematical laws do, however, show that the convection theory is a possible one, and taken in connection with the principle of the conservation of energy, and the numerical value of the mechanical equivalent of heat, as determined by Joule, a simple calculation shows that the latent heat set free by the condensation of sufficient moisture to produce a few hundredths of an inch of rain, will, if it take the form of kinetic energy, be sufficient to produce a most violent storm.

Van Bebber asserts that the storms move so that they have the highest temperature on the right hand of their track. The

greater number, undoubtedly, progress toward some easterly point, corresponding in this with the upper currents; and in these cases the higher temperature is naturally found on their right hand, *i. e.*, in the lower and, therefore, warmer latitude. If, however, it is found that the rule holds in the exceptional cases when the motion is westward, and that the air is then warmer and moister on the north side, the fact will go a long way towards proving the truth of Ferrel's theory. It is often stated that the eastward motion is due to the continual reproduction of the storm in front of itself, brought about by the warm southerly current which prevails in that part; and, assuming the truth of the convection theory, the explanation is a very plausible one. The eastward motion cannot be adduced in support of the theory, because the motion of the upper currents is also eastward. If, however, it be a fact that in the rare instances of the reverse motion, the northerly wind on the western side is the warmest and dampest, the simultaneous occurrence of two exceptional phenomena will show that they are not independent of each other, and will lead to the conclusion that cyclones are caused by convection.

Oxshott, Leatherhead, England, Oct., 1894.

RECENT FOREIGN STUDIES OF THUNDERSTORMS: V. RUSSIA.*

R. DeC. Ward.

IN 1871, at the suggestion of Dr. A. Wœikof, the Imperial Geographical Society of Russia instituted a special study of thunderstorms, which has been continued until the present time. The materials thus collected have been studied by Wœikof, Klossovsky, Schœnrock, and Berg. The first comprehensive report was one by Klossovsky, published in 1884 in the Russian language, and followed, in 1886, by an abstract in French of the original memoir (*Les Orages en Russie.* 8vo. Odessa, 1886. pp. 32). This report has been summarized by Prof. W. M. Davis

* The previous papers of this series will be found in this Journal, Vol. IX., pp. 532–541 (Great Britain); Vol. X., pp. 111–126 (Germany); pp. 178–184 (France), and pp. 411–420 (Italy).

in his paper on "Recent Foreign Studies of Thunderstorms" (see this JOURNAL, Vol. III., pp. 43–46).

The more recent publications on the thunderstorms of Russia are as follows: —

A. SCHŒNROCK. *Die Gewitter Russlands im Jahre* 1884. Repert. Met., St. Petersburg, X., 1887, No. 6. 32 pp., 1 table. 4to. St. Petersburg, 1887.

A. SCHŒNROCK. *Die Gewitter Russlands im Jahre* 1885. Repert. Met., St. Petersburg, XI., 1888, No. 3. 37 pp., table. 4to. St. Petersburg, 1887.

E. BERG. *Die Gewitter Russlands im Jahre* 1886. Repert. Met., St. Petersburg, XIII., 1890, No. 5. 51 pp., table. 4to. St. Petersburg, 1890.

E. BERG. *Die Bedeutung der Absoluten Feuchtigkeit für die Entstehung und Fortpflanzung der Gewitter.* 4to. St. Petersburg, 1888. Repert. Met., St. Petersburg, XI., 1888, No. 13. 19 pp., 1 table.

A. SCHŒNROCK. *Beitrag zum Studium der Gewitter Russlands.* Repert. Met., St. Petersburg, XI., 1888, No. 12. 18 pp., 1 table. 4to. St. Petersburg, 1888.

E. BERG. *Untersuchung eines Wintergewitters.* Repert. Met., St. Petersburg, XII., 1889, No. 13. 28 pp., 1 table. 4to. St. Petersburg, 1889.

A. SCHŒNROCK. *Specielle Untersuchung der Gewitter in Russland im Jahre* 1888. Repert. Met., St. Petersburg, XIII., 1890, No. 11. 18 pp. 4to. St. Petersburg, 1890.

The above-mentioned publications being inaccessible to the present writer, he has had to depend on the reviews published in the *Meteorologische Zeitschrift.*

The report on the thunderstorms of 1886, by Berg, has been briefly reviewed by van Bebber in the *Meteorologische Zeitschrift,* Vol. 7, 1890, pp. (54)–(55). The number of thunderstorm reports received in 1884 was 4,702; in 1885, 7,196, and in 1886, 9,544. An interesting comparison of the numbers of observing stations in different countries is made by the author with the following result: Number of stations in each district of 10,000 sq. kms.: France, in 1882, 66.2; Italy, in 1883, 27.1; Bavaria, Wurtemberg, and Baden, in 1886, 28.7; European Russia, in 1886, 1.3.

The district of greatest thunderstorm activity is the Caucasus; then the southern central region; then follow the eastern and southern areas. The district of least activity is the northern part of the country, where the frequency is one half of that in the Caucasus. If the absolute number of days on which thun-

derstorms occurred is alone taken into consideration, and not, as in the preceding sentences, the number of thunderstorm days, together with the distribution of thunderstorms on those days, then it is found that the southern zone has the greatest number of absolute thunderstorm days, followed by the southern central zone, and then by the Caucasus. In this case, as in the previous one, the northern zone has the smallest number of thunderstorm days. On the other hand, the mean distribution of storms, in percentages of the area of each zone, shows that the Caucasus region has the greatest distribution, while the southern zone has the smallest. The four northern zones have their maximum thunderstorm activity in July, the four southern zones have theirs in June. The predominant direction of movement is northeast. The spring and autumn thunderstorms are more often accompanied by hail than the summer thunderstorms in most of the zones. The time of greatest frequency of thunderstorms is found to be between 3 and 4 P. M., one hour earlier than in 1885. The minimum is between 4 and 6 A. M. The conclusion as to the dependence of thunderstorms on cyclones is that the cyclones which develop thunderstorms have an especially high degree of relative humidity, in addition to high temperature.

The special report on the thunderstorms of 1888, by Schœnrock, summarized in the *Meteorologische Zeitschrift*, Vol. 8, 1891, pp. (39)–(40), deals with the rate of progression, the duration, and the distance travelled. In all, 197 separate progressive thunderstorms were definitely determined during the year, lasting in all 1,034 hours, and crossing districts of 47,182.9 kms. in extent. July had the maximum number of thunderstorms, 75, while August had 48, June, 25, and May, 23. The mean duration of the storms is less in the colder months than in the warmer; from May to August the mean duration is 5.3 hrs.; in March, April, September, and October, 4.6 hrs. The velocity of progression is greater in the cold months than in the warm, the figures standing 51.5 kms. per hour and 44.9 kms. per hour. The velocity varies between 20 and 80 kms. an hour, the actual mean being 45.6 kms. This velocity is greater than that found for western Europe, probably owing to the generally level character of the surface. Thunderstorms of long duration move more rapidly than those of short duration.

The daily period of velocity is well marked. If the mean velocity of a thunderstorm is taken as occurring at the mean time of its occurrence, the minimum velocity is found to occur at 2 A. M. (27.8 kms.) and the maximum at 9 P. M. (51.9 kms.). Thunderstorms moving from the western quadrants have the greatest velocity, those from the eastern the least (45.1 kms. and 38.8 kms. respectively). There seems to be a decrease of velocity of movement towards the north; although the influence of latitude is not very clear. The maximum frequency of thunderstorms is between 5 and 6 P. M., with a second slight maximum at 4 A. M. and another at 9 P. M. During the cooler months, the majority of thunderstorms begin between 3 and 4 P. M.; in May, between 12 M. and 1 P. M.; in June, between 9 and 10 A. M.; in July, between noon and 1 P. M.; and in August, between 2 and 3 P. M. This indicates that the development is not alone dependent on the diurnal temperature curve. The average direction of movement seems to depend on the latitude. North of lat. 51° N., the prevailing direction from which the storms come is S. 63° W., while south of latitude 51° N., the movement is directly from the west. By arranging the thunderstorms according to their places of origin, it appears that 33% begin between 35° and 40° E. long., and from here the number of thunderstorms decreases towards east and west in all latitudes.

The general paper on *Die Bedeutung der absoluten Feuchtigkeit für die Entstehung und Fortpflanzung der Gewitter*, reviewed in the *Meteorologische Zeitschrift*, Vol. 5, 1888, contains the results of some observations in connection with thunderstorms at Pawlowsk in 1885, 1886, and 1887. The author finds that thunderstorm days are distinguished from days which do not develop thunderstorms by a high absolute humidity, and that a maximum of absolute humidity is always present at a station shortly before the passage of the thunderstorm. If two storms follow one another closely, each one is distinguished by a maximum vapor tension, with a minimum between. The maximum temperature precedes the time of maximum vapor tension. Charts of the storms of May 4, 1887, and of May 31, 1886, showing the isobars and lines of equal vapor tension, make it evident that there is an area of high vapor tension in front, and an area of low vapor tension in the rear of a thunderstorm. The thunderstorm front is

seen to be much influenced by the distribution of the humidity in front of the storm.

The work done in connection with thunderstorms in Russia during the last few years has given us many valuable results, as has been seen in the previous paper by Prof. Davis on this subject, and in the present brief summary. In connection with the subject of the thunderstorms of Russia, mention should be made of the chart of thunderstorm distribution over the world, recently prepared by Dr. A. Klossovsky of the University of Odessa, which has already been reviewed in this Journal (Vol. XI., p. 353).

Harvard University, December, 1894.

GULF STORM NOTES.

WILFRID D. STEARNS.

THE notes on the tropical storm of Oct. 4 to 11, which follow, are presented in the belief that they will be of interest, since they are a faithful record of certain local weather phenomena observed in this vicinity during the passage of the storm. Although the disturbance moved approximately from south to north in the meridian of New Orleans, and, therefore, was indicated first (in the northern gulf) at that city instead of Galveston, as would have been the case had it recurved further to the westward, the observed phenomena are regarded as substantiating, in part, the principles stated in "Storms of the Gulf of Mexico and their Prediction." * The very slow motion of the disturbance having given time for the passage of low and high areas to the northward, the evidential value of the local phenomena, while each condition prevailed, is a question offered for consideration.

In attempting to determine the presence of storms in the gulf, I have found that the northeast to southwest motion of isolated masses of high cumulus is an insufficient indication, without accompanying well-marked sea phenomena, since it is present, particularly early in the autumn, with weak depressions which may or may not reach land ; yet, in the hurricane

* American Meteorological Journal, April, 1894, 497–504.

season, it would seem that this motion of the higher cumulus should always be accepted as a warning signal, emphatically so if it occurs with an energetic low area to the northward.

The splendid work of the Weather Bureau in following and giving adequate warning of this great storm, belonging as it does, to a class very destructive and yet, perhaps, the most difficult of all to predict, cannot be too highly valued and commended.

OCTOBER 4. 9 A. M. Cumulus, higher and lower, from the northeast; cirrus and cirro-stratus from west, or slightly south of west; motion of cumulus, moderate; of cirrus and cirro-stratus, rapid.

Numerous convection showers have been seen to form, but their base being carried rapidly to the westward, they have quickly dissipated.

6 P. M. No cumulus. At 5 this afternoon observed a slight swell from the east; sea rather smooth; tide strong, but not excessive; air "suffocating" yesterday and to-day, but fresher this afternoon, with a north breeze.

OCTOBER 5. 7 A. M. High wind the latter part of the night from northeast; still continues. Cirrus streamers moving rapidly from southwest; sea rough; surf from east; a long swell and water covered with foam from short surface waves.

5 P. M. Sea rougher than this morning, with a longer and stronger swell from the east; a somewhat choppy sea. The cirro-stratus shows a peculiar formation [streamers passing from northwest and terminating towards southeast in an elevated feather-like form, from which fine streamers pass back towards the northwest, where they, in turn, end in an uplifted feather extremity], the whole drifting from the west and southwest.

NOTE. Weather Bureau reports, at 1 P. M., the storm central between Cuba and Yucatan.

OCTOBER 6. 7 A. M. High tide this morning; a cross sea from the east; long swell and very heavy surf; clear, except a few cirri in northeast, and a band of low scud cloud in the southeast.

5 P. M. Sea fully as rough, if not rougher than this morning; swell heavier; the undulations have veered so that they are coming from a more southeasterly direction than this morning. Weather hazy all day; cloud in the southeast disappeared about 10 o'clock, but is again visible to-night. The cirrus in

the northeast occupies about the same position as this morning. The cirri have an apparent motion from west to east. At sunset to-night the sky was of a very marked yellow copper color, and more than ordinarily brilliant; wind east-northeast.

NOTE. Information signal was lowered at 2 P. M. (Eastern time) to-day.

From the appearance of the sea, I think the storm must now be in the central gulf, moving west. I attribute the falling off in the wind to-night to the effect of the northern low area. That it has persisted from the east and northeast is the best possible evidence that the gulf storm still exists. [Weather Bureau reported it south of New Orleans late on the night of the 6th.]

OCTOBER 7. 6.30 A. M. Wind northeast. Tide very high; in part covering sand flats, and backing into gutters; swell very long; waves rising and receding on the beach a distance of thirty or forty feet; direction of swell still from southeast and east, making a choppy sea. Before the sun rose this morning, a cloud-cap of cirro- (or high cumulo-) stratus, forming a dense bank with wavy top, was visible in east-southeast. As the sun rose, the cirrus edge showed a slow motion from south to north across the face of the sun (this cannot be positively stated, however), which would place storm central southeast. Storm, two hundred miles southeast.

It is worthy of note that a few minutes after sunrise, owing to the hazy atmosphere over the sea, and the general brightness, this bank of cloud became almost invisible. I think the storm will strike the coast near New Orleans late to-night.

11.30 A. M. Tide still continues to rise. Cirro-stratus or cumulo-stratus bank has risen to about 20° of angular magnitude above the horizon.

4 P. M. Tide still continues high; surf and swell heavier and longer, respectively. Below the cirro-stratus a broad band of black-looking stratus appeared about 11.30 A. M., and has persisted until now, increasing in width, and extending to south and southwest. Small detached cumulus masses appeared about 2 P. M. in the east, and some are now overhead, showing motion towards southwest.

6 P. M. About eight tenths of the sky covered with masses of low cumulus and cumulo-stratus. They move quite rapidly from the east-northeast, but for an hour there has been an abso-

lute calm; not a leaf moves. Cirro-stratus bank has risen to about 30° above horizon, and extended north and south.

7 P. M. Still calm. Sunset showed red (brick-dust color) similar to that of the 6th.

10.30. Clouds, except cirro-stratus in southeast, disappeared a few moments after sunset; night very bright; not a particle of haze or vapor discernible about tbe moon; wind began to blow after seven from the north in gusts; noise of surf very great.

OCTOBER 8. 7.30 A. M. The bank of cirro-stratus or cumulo-stratus has retreated towards the southeast to about 20° altitude, but has extended towards the northeast. Sea still undiminished; tide covers the flats; high north winds. 12 M. Cumulo-stratus bank still visible in the east, but getting low on the horizon.

1.30 P. M. Cloud bank about 5° above horizon in the east-northeast, and, on account of haze, barely visible.

GALVESTON, TEXAS, November, 1894.

PSYCHROMETER STUDIES.

PROF. H. A. HAZEN.

IN the July number of this JOURNAL I called attention to some extraordinary views regarding the psychrometer promulgated by Dr. Ekholm, of Stockholm, and tried to show that all the difficulties met by him could be overcome if a ventilated psychrometer is employed, and if proper allowance is made for the contraction of the ice film. In the December number, page 289, Dr. Ekholm admits the justness of my position regarding the contraction of the ice, but does not think that this accounts for all the difficulty, since, in addition to this contraction, there is a supposed error, in that the latent heat is greater for ice than for water. It is very difficult to understand how Dr. Ekholm has fallen into the errors he has in studying this question, though the use of a stationary psychrometer will account for a good deal of the trouble. As I have shown repeatedly, such an instrument is entirely useless in studies of this problem.

On page 293, he agrees with my statement that water and ice may both exist on different bulbs at the same time and give ab-

solutely the same psychrometric result. This is the essence of the whole question, and, in admitting this, he admits that the theoretical difference between the latent heat of ice, as compared with that of water, does not enter the problem at all. With these two admissions, it is a matter of great wonderment that he requires eight pages to dispute these points which he himself accepts.

Dr. Ekholm adopts a novel device for overcoming the pressure of ice. This consists in first making a very thin metallic shell just a little larger than the thermometer bulb and filling this with mercury; now, when the shell is covered with ice, the pressure is relieved from the bulb by the mercury. In some experiments in nearly saturated air this shell, with its ice coat, gave —7.0° Fahr., and the ice covered bulb without the shell gave —7.8°! That is, the experiment showed that with the total ice compression, whatever that might have been, plus the effect of latent heat, there was a *lower* reading than was shown by the other bulb with the compression removed. I do not see how anything could be stated to throw a greater cloud upon this work. His own observations disprove his claims or show that there has been a most serious blunder somewhere.

But this is not all. In order to clinch his argument, that the vapor pressure of water is greater than that of ice, and for this reason the ice covered bulb must read higher than that with water, he makes a few experiments at about 32°, when the contraction of the ice film must be insensible. I do not agree that this need be the case invariably. It is not difficult to consider that there might be cases in which the outer portion of the water film would freeze first, and, if so, the farther freezing might cause a pressure. I do not throw this out, however, as explaining what follows. In a series of experiments he found these readings: —

Dry.	Water.	Ice.
29.6°	29.6°	29.9°
30.3°	30.15°	30.3°

That is, the ice covered bulb gave a reading about .2° Fahr. *higher* than the water covered. Here, then, would seem to be a proof of his proposition, that, in a saturated air, the ice covered bulb reads higher because the latent heat of evaporation is greater

for ice than for water. This is really a contradiction, for in a saturated air there is, and can be, no evaporation at all.

But, again, this is not all. Most careful experiments in Minnesota, with an almost perfect apparatus for determining this question, and later, Prof. Marvin, with an apparatus greatly improved, showed that near the freezing point the vapor pressure of water is absolutely the same as that of ice. It seems to me that this fact disproves most effectually all these fine spun theories. On page 295, Dr. Ekholm gives the results of a few experiments to determine the addition of ice vapor to an ice covered bulb in the air. The desire was to disprove my statement that the ice covered bulb must lose its weight in the air. He found an addition of two and three milligrams twice. This is a very remarkable result, and cannot be explained. If Dr. Ekholm will pour some water on a stone step, or on any solid where it cannot be absorbed, when the temperature is 10° or 15° below freezing, he will very quickly find that the ice will entirely disappear. If all this discussion shall prove that nothing can be done with a still psychrometer, and shall lead to a better understanding of this problem abroad, it will be of great benefit.

DEC. 3, 1894.

THE MOON AND RAINFALL.

PROF. H. A. HAZEN.

WHILE in New Haven, Conn., in 1880, I made a special investigation of the expression, "The weather will not change until the moon changes," a very familiar saying in some quarters. I found the ideas in regard to the expression extremely dim and undeveloped, but the final outcome of the study was that more rain was to be expected at the time of new than full moon. I also found that many had the idea that a thunderstorm could visit Long Island Sound only upon a rising tide; that during a falling tide it would be dissipated. It would seem as though such a question as the influence of the moon on rainfall would be a most admirable one to settle by means of actual data, and I accordingly put the question to the test by using the precipitation records of the Weather Service at New Haven. I found that nearly one half more precipitation occurred at the time of new than of full moon. I allowed the

matter to rest at this time till there were more records. The record of one hundred years at London yielded a negative result.

A study of the rainfall, published in the *International Bulletin* for the whole country, also yielded a negative result, and showed that the influence, if there were one, must be looked for in a rather circumscribed region. In "Congress" for June, 1888, page 95, I published a statement that, in some places, more rain fell during new than during full moon. The same statement will be found in "Science" for July 18, 1890, and Dec. 2, 1892. It has seemed to me that it might be wise to put this question to the test of twenty-three years' records in the region where it was first discussed. I arranged the rainfall at New York City, New Haven, Conn., and Boston, Mass., according to each lunation, and then summed the 296 lunations in three groups of nearly 100 lunations each. The results for each station will be found in the accompanying table. The fourth horizontal row contains the mean of the three rows, and the fifth has the sums of each consecutive five observations. If any one will project these figures he will find very remarkable coincidences throughout, and a shifting of the curve one day to right or left will eliminate nearly all remaining discrepancies. When we consider that there are 296 lunations in the last set of figures for each station, or, what is the same thing, the rainfall for 296 days, it is very remarkable that all the crests and hollows are not smoothed out. While both New York and New Haven show an increase at the time of new moon, yet the figures at Boston show a very remarkable maximum at the day of new moon, and an equally remarkable minimum on the seventeenth day of the lunation, or two days after full moon. I do not set forth these figures as an absolute proof that the moon does influence rainfall in the neighborhood of Boston, but it looks as though there must be something in it. There are at times remarkable reversals in the curves whereby a minimum point in one curve coincides with a maximum in the next, but to offset these there are remarkable coincidences; for example, a marked maximum at the twentieth day of the lunation throughout. It will require a good many more observations to prove anything one way or the other, but it would seem as though the curve at Boston could not be very materially modified with less than 50 years' observations.

Nov. 7, 1894.

RAINFALL AT NEW YORK CITY BY LUNATIONS.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	2.1	1.3	.7	1.2	1.2	1.0	1.2	1.3	1.2	1.0	1.7	1.4	1.3	1.0	.8	1.0	.8	1.1	.9	1.3	1.8	1.2	1.3	1.2	1.0	.8	1.1	1.8	1.6	1.1
	1.0	1.6	1.1	1.6	1.2	.9	.9	.8	1.3	1.2	1.2	2.4	1.0	1.3	1.2	1.0	1.2	1.1	.6	.9	1.5	1.0	1.2	1.3	.8	1.3	.9	.9	1.0	1.2
	1.4	1.0	1.2	1.7	2.4	1.7	1.2	1.1	.7	1.3	1.0	.8	1.0	1.4	1.3	1.5	1.8	1.0	1.2	1.5	2.1	.8	1.3	.8	1.1	1.2	1.2	1.4	1.4	1.1
Mean.	1.5	1.3	1.0	1.5	1.6	1.2	1.1	1.1	1.1	1.2	1.3	1.5	1.1	1.3	1.1	1.2	1.2	1.1	0.9	1.2	1.8	1.0	1.3	1.1	1.0	1.1	1.0	1.3	1.3	1.2
	18.8	19.2	20.5	19.6	19.0	19.3	18.2	16.8	17.2	18.5	18.6	19.2	19.0	18.7	17.8	17.7	16.5	16.9	18.7	18.0	18.5	19.1	18.3	16.2	16.3	16.6	17.4	18.0	19.1	19.9
NEW HAVEN, CONN.																														
	2.0	2.0	.7	1.1	1.5	1.1	1.1	1.3	1.4	1.8	1.5	1.5	1.0	1.1	1.1	1.5	1.0	.8	.8	1.2	1.7	1.0	1.0	1.4	1.3	1.5	2.3	1.7	2.0	1.6
	1.3	.8	1.4	1.3	1.0	.6	.6	.7	.9	1.7	1.0	1.2	1.4	1.0	.9	.9	1.1	.6	.8	.9	1.0	.8	1.0	1.0	1.4	1.2	.8	.8	.7	1.0
	1.0	1.4	1.6	1.6	1.7	1.3	1.4	.8	1.4	.8	.7	1.1	1.4	1.2	1.4	1.5	1.6	1.2	1.3	1.0	1.6	1.4	1.0	.9	1.4	1.1	1.3	1.0	.5	1.5
	1.5	1.4	1.2	1.4	1.4	1.0	1.0	.9	1.3	1.4	1.1	1.3	1.3	1.1	1.1	1.3	1.2	.9	.9	1.1	1.4	1.1	1.0	1.1	1.4	1.3	1.5	1.2	1.1	1.3
	19.6	20.5	20.6	19.2	18.1	17.2	16.9	17.0	17.3	17.9	19.1	18.6	17.6	18.2	18.2	16.9	16.4	16.2	16.6	16.1	16.5	16.9	17.8	17.4	18.5	19.1	19.0	18.9	1.95	19.3
BOSTON, MASS.																														
	1.1	2.1	1.1	1.5	1.3	1.1	1.9	1.3	1.8	1.2	1.8	1.4	1.3	1.0	1.4	.8	1.8	1.2	1.1	1.0	1.4	1.7	1.0	.8	1.5	1.5	1.7	1.5	2.6	1.8
	1.5	1.4	1.7	1.0	1.6	.9	.8	.9	.9	1.9	1.1	1.4	1.2	1.1	1.5	1.1	1.2	.9	.9	1.2	1.1	1.3	1.1	1.2	1.3	1.4	1.0	.9	1.2	1.2
	.9	.8	1.1	1.2	1.3	1.3	1.6	1.0	.8	.9	.9	.8	.9	.6	1.1	1.0	1.0	.5	.7	1.3	1.5	.9	1.1	.9	1.4	.9	1.3	.7	.9	.8
	1.2	1.4	1.3	1.2	1.4	1.1	1.4	1.1	1.2	1.3	1.3	1.2	1.1	.9	1.3	1.0	1.3	.9	.9	1.2	1.3	1.3	1.1	1.0	1.4	1.3	1.4	1.0	1.6	1.3
	20.1	19.0	19.5	19.3	19.5	18.9	18.7	18.5	18.9	18.2	18.2	17.3	17.3	16.4	16.8	16.1	16.2	15.6	16.8	16.7	17.3	17.5	18.2	18.0	18.2	18.1	19.9	19.5	19.1	19.2

RHYTHM IN THE WEATHER.*

H. HELM CLAYTON.

TO most persons nothing seems more irregular and fitful than the weather. Yet I think there is good reason to believe that through all this seeming irregularity there runs a web of harmony and rhythm.

The yearly and daily weather periods are well known, but these, I believe, are not the only regular periods to be found. A year ago I described to the Society two rhythmic periods in the weather, one of about 7¼ and the other of about 6⅛ days in length. To these I will now add two shorter periods, one of 5 days 10.8 hours and the other about 4 days 15 hours. The action of these on the atmosphere is usually in combination, but they independently vary in intensity, so that now one and now the other predominates and gives its especial characteristics to the weather changes. Their action may be compared to waves on the surface of water formed by throwing pebbles into the water. If one pebble is thrown in, a series of regular waves is set up and plainly visible. If two or more are thrown in at the same time, and fall near together, there is set in motion a series of waves which overlap and produce a complex set of oscillations in which it is difficult to detect any regularity.

A still better analogy is to compare the weather rhythms with the sound waves set up by striking the string of a musical instrument. It is well known that in this case not only a fundamental note is originated but other waves, called harmonics, are set up which are related to the length of the first in the proportion of 2, 3, 4, 5, etc. So the four weather rhythms spoken of above, which may be compared to the vibrations emanating from the strings of a musical instrument, are each related to longer periods of the nature of harmonics. Thus there are found weather periods of 3⅝, 7¼, 14½, 29, 58, etc., days, and others of 5½, 11, 22, 44, etc., days.

I could not in a brief talk give one tenth of the evidence I have for believing in the existence of this complex system of

* Read before the Boston Scientific Society, Nov. 13, 1894, and published in the Boston *Commonwealth* for Nov. 17, 1894.

rhythms. Last year I gave the Society an account of the evidence gathered concerning the existence of the six-day and seven-day periods, and showed that they had maintained their regularity at Blue Hill Observatory and at other parts of the United States. By aid of a grant from the Elizabeth Thompson fund, I am now investigating these periods for every part of the world. The results are not yet ready for publication, but they indicate unmistakably that the periods exist in every part both of the northern and southern hemispheres.

During the present year, the $5\frac{1}{2}$ and $7\frac{1}{4}$ day periods, and their multiples, have been predominant in their influence on the weather, and as one illustration of the evidence of their existence, I give herewith the dates of highest temperature recorded at Blue Hill Observatory during May and June. These are the dates on which occurred the highest point reached during each successive warm wave. Thus the temperature reached 87° on May 2, then fell regularly till May 4, rose again to 77° on May 7, fell to the 10th, etc. : —

Dates of highest temperature	May 2, 7, 13, 17, 23, 27, June 4.
Dates of $5\frac{1}{2}$ day period	May 2, 7, 13, 18, 23, 29, June 3.
Dates of $7\frac{1}{4}$ day period	May 6, 13, 20, 27, June 4.
Dates of maxima	June 11, 17, 23, 27.
Dates of $5\frac{1}{2}$ day period	June 11, 17, 22, 27.
Dates of $7\frac{1}{4}$ day period	June 11, 18, 26.

Beginning with May 2, 6 A. M., and again with June 11, 4 P. M., and adding 5 days 10 hours successively, a series of dates is obtained representing the $5\frac{1}{2}$ day period. Beginning with May 6, 4 A. M., and adding successively 7 days 6 hours, a series of dates is obtained representing the $7\frac{1}{4}$ day period. These dates are given below the dates of observed maximum temperature, and the coincidence between the dates, I think, will be evident to most people.

There is one point, however, to which it is necessary to call attention; and this is, that between June 3 and 11, is not one but one and a half of the $5\frac{1}{2}$ day period. This illustrates where the analogy between these weather waves and sound waves breaks down. When sound waves of different length interfere, they rebound and continue on as before. But in the interference of these weather waves, as in the case of the five-day and seven-day

shown above, one of the two is frequently destroyed, or has its phase reversed. Technically speaking, a cyclone and an anti-cyclone cannot exist at the same time, or come together and produce a calm.

This fact is the greatest obstacle which now stands in the way of using these periods in forecasting. If the periods kept steadily on, like sound waves, it would be comparatively easy to separate them and plot them in advance; but when they are reversed by interference, the usual methods of analysis fail, and we are left to rough and approximate methods of separating the periods. During the summer I computed a series of normal waves for each of the periods, and by taking the times of maxima and minima and the amplitude from observation, I found it possible to reproduce the observed temperature with great accuracy, and even to plot a curve for a week in advance which would represent the observed temperature or pressure very closely as long as the periods continued to run without a break. These predicted curves were sent as soon as made to Mr. Paul S. Yendell, who offered to verify the forecasts as a matter of scientific interest. He took regular observations and recorded them on the same chart with the predicted curve, and then returned them. I exhibit several of these,* and desire especially to call attention to the temperature curve for the week beginning August 18. It will be seen that the predicted and observed temperature followed almost exactly the same course; but what is most remarkable is the fact that the predicted minimum temperature and the observed minimum temperature was the lowest observed in August for more than nine years.

After I had made some progress in the investigation of these weather periods, an experiment was begun to ascertain how far they could be made useful in forecasting. Beginning with January 27, forecasts were published each week in a local newspaper. These forecasts consisted in stating which days were likely to be warmest and coldest, and on which rain or snow was most likely to fall. After two months these were verified, and it was found that of 17 days, mentioned as days on which rain was probable, rain fell on 12; while on the average for each 17 days not mentioned, rain fell on 5, indicating that the percentage

* These charts are omitted here.

of rain was twice as great on days when rain was forecasted as on other days. Two days were named each week as likely to be the warmest days. In six weeks out of eight, the warmest day of the week occurred on one of these. The coldest days were predicted in a similar manner, and in four cases out of eight the coldest day of the week occurred on one of the days predicted. Since two days were included in each week, the chances were that 2 out of every 7, or 28 per cent, might prove accidentally correct, while in reality 75 per cent of the warmest days were correctly predicted, and 50 per cent of the coldest.

These facts appeared to indicate that the forecasts might prove of benefit to farmers and others, and accordingly on June 2 the issue of a weekly bulletin for general distribution was begun. These bulletins met with an encouraging support, and it was decided to continue them through the year. At the end of September, a verification of the forecasts was made, and it was found that out of 20 warm intervals predicted 13 averaged warmer than the mean of the week, and out of 19 cool intervals predicted 12 averaged cooler than the mean of the week, or about two-thirds in each case. A measurable quantity of rain fell on 33 per cent of the days on which rain was predicted, and on 20 per cent of the days on which no rain was predicted. Reports sent me from various stations indicate that this held substantially true for all of southern New England. The forecasts were made on Friday, and the success for the five days from Monday to Friday was about the same as for the other days.

The excess in favor of the forecasts is not so great as I had at first hoped, but shows, as fully as it is possible to do, that the forecasts have a scientific basis, and are not merely the result of guesswork.

Besides the sudden change in phase of the periods mentioned above, I have encountered other, and in some cases unexpected, difficulties. During October there existed two sets of storms, one coming over New England from the lakes, and another from the south. The results were too intricate for my analysis, and produced a series of disheartening failures in the forecasts.

Difficulties are to be expected in a new enterprise, but I am confident that they will be solved, one by one, until an exact science of the weather is constructed. Mr. Rotch has encouraged these investigations as a part of the work of the Blue Hill

Meteorological Observatory, and in this way has, I think, contributed greatly toward this end.

I can point to the successful forecasting of a hot, dry period in the beginning of May, to a cool, rainy period near the end of May, to a hot, dry period in the middle of June, to a cool period in August, and to a rainy period after a long drouth commencing during the latter part of September or first of October; and I take this as substantial evidence that the right clue to long-range weather forecasting has been found, and will some day be perfected. Whether present knowledge is sufficient to warrant forecasts being made, will, of course, call forth differences of opinion. To those who expect great accuracy, or who have decided in advance that the coming weather cannot be forecasted on this basis, it will probably seem premature; but to those who appreciate the difficulties, and keep in mind the fact that the successes exceed the failures, the forecasts will prove of value, as they have already to many whose interests are affected by the weather.

CURRENT NOTES.

Weather Making, Ancient and Modern. Prof. Mark W. Harrington, Chief of the Weather Bureau, has a paper on "Weather Making, Ancient and Modern," in the National Geographic Magazine, Vol. VI., 1894, pp. 35–62. The first part of the article is taken up with a consideration of superstitious and religious methods of weather making, and the last part with the modern, and mainly American, schemes of producing artificial rain. The latter division of the subject has been fully treated in this JOURNAL. The following extracts are from the first division of Prof. Harrington's paper, pp. 35–46: —

"The subject of ancient and modern weather making is a very large one, — too large to be treated with entire generality. I shall discuss it rather from the American standpoint, and shall use cases in the Old World simply for the purpose of illustration and for completeness.

"Three distinct sorts of weather-making have been employed. The first depends on superstitious and religious methods; then follows on this the degradation of these religious ideas into folk-lore remnants, which have a curious persistency in civilized countries. Both these are psychic. Opposed to them is the third method, mainly American and intensely practical, with which some history and literature are connected.

"Many Indian tribes have attempted to produce rainy or dry weather, according to requirements. Among these may be mentioned the Mandan, the Muskingum, the Moqui, the Natchez, Zuñi, Choctaws, and others. For this purpose pipes were smoked, tobacco was burned, prayers and incantations were offered, arrows were discharged toward the clouds, charms were used, and various other methods were employed. Classifying by tribes the processes employed, we turn first to the Iroquois.

"Mrs. E. A. Smith, in her 'Myths of the Iroquois,' says: —

"'In a dry season, the horizon being filled with distant thunder-heads, it was customary to burn what is called by the Indians real tobacco as an offering to bring rain.

"'On occasions of this nature the people were notified by swift-footed heralds that the children, or sons, of Thunder were in the horizon, and that tobacco must be burned in order to get some rain.' *

"As to the Muskingum, Heckewelder, in his 'Account of the Indians of Pennsylvania' (Philadelphia, 1819, page 229), says: —

"'There are jugglers, generally old men and women, who get their living by pretending to bring down rain when wanted, and to impart good luck to

* 2d Ann. Rep. Bureau of Ethnology for 1880–'81 (1883), p. 72.

bad hunters. In the summer of 1799 a most uncommon drought happened in the Muskingum country (Ohio). An old man was applied to by the women to bring down rain, and, after various ceremonies, declared that they should have rain enough. The sky had been clear for nearly five weeks, and was equally clear when the Indian made this declaration; but about four o'clock in the afternoon the horizon became overcast, and, without any thunder or wind, it began to rain, and continued to do so until the ground became thoroughly soaked.'

"Heckewelder adds that 'Experience had doubtless taught the juggler to observe that certain signs in the sky and in the water were the forerunners of rain.'

"Among the Natchez, according to Father Charlevoix,* jugglers not only pretended to cure the sick, but also professed to procure rain and seasons favorable for the fruits of the earth. Their incantations were often directed to the dispersion of clouds and the expulsion of evil spirits from the bodies of the afflicted.

"In the third report of the Bureau of Ethnology it is stated by J. Owen Dorsey that 'When the first thunder is heard in the spring of the year the Elk people [among the Omaha Indians] call to their servants, the Bear people, who proceed to the sacred tent of the Elk gens. When the Bear people arrive one of them opens the sacred bag and, after removing the sacred pipe, hands it to one of the Elk men, with some of the tobacco from the elk bladder. Before the pipe is smoked it is held toward the sky, and the thunder god is addressed. . . . At the conclusion of this ceremony the rain always ceases, and the Bear people return to their homes.'†

"Catlin, in his 'Life among the Indians' (page 78), says that he found that the Mandan had 'rain-makers' and also 'rain-stoppers,' who were respected medicine men, 'From the astonishing facts of their having made it rain in an extraordinary drought, and for having stopped it raining when the rain was continuing to an inconvenient length.' He adds: —

"'For this purpose, in a very dry time, the medicine men assembled in the medicine lodge, and sitting around a fire in the centre, from day to day, smoking and praying to the Great Spirit for rain, while a requisite number of young men volunteered to make it rain. Each one of these, by ballot, takes his turn to mount to the top of the wigwam at sunrise in the morning, with his bow and arrows in his hand and shield on his arm, talking to the clouds and asking for rain, or ranting and threatening the clouds with his bow, commanding it to rain. After several days of unsuccessful attempts have passed off in this way with a clear sky, some one more lucky than the rest happens to take his stand on a day on which a black cloud will be seen moving up. When he sees the rain actually falling he lets his arrow fly, and pointing says: "There! my friends, you have seen my arrow go. There is a hole in that cloud. We shall soon have rain enough." When he comes down he is a medicine man. The doctors give him a feast and a great ceremony and the doctor's rattle. When the doctors commence rain-mak-

* Voyage to North America, Dublin, 1776, Vol. II., p. 203.

† Omaha Sociology, op. cit., 1884, p. 227.

ing they never fail to succeed, for they keep up the ceremony until the rain begins to fall. Those who have once succeeded in making it rain, in the presence of the whole village, never undertake it a second time. They would rather give other young men a chance.'

"A similar account of the Mandan ceremony is given by Mr. John Frost, in his book, 'The Indians of North America' (New York, 1845, page 109). He says:—

"'It was in a time of great drought that I once arrived at the Mandan village on the upper Missouri. The young and the old were crying out that they should have no green corn. After a day or two the sky grew a little cloudy in the west, when the medicine men assembled together in great haste to make it rain. The tops of the wigwams were soon crowded. In the mystery lodge a fire was kindled, around which sat the rain-makers, burning sweet-smelling herbs, smoking the medicine pipe and calling on the Great Spirit to open the door of the skies to let out the rain. At last one of the rain-makers came out of the mystery lodge and stood on the top of it with a spear in his hand, which he brandished about in a commanding and threatening manner, lifting it up as though he were about to hurl it at the heavens. He talked loud of the power of his medicine, holding up his medicine bag in one hand and his spear in the other; but it was of no use, and he came down in disgrace. For several days the same ceremony continued, until a rain-maker, with a head-dress of the skins of birds, ascended the top of the mystery lodge, with a bow in his hand and a quiver at his back. He made a long speech, for the sky was growing dark, and it required no great knowledge of the weather to foretell rain. He shot arrows to the sunrise and sundown points of the heavens, and also to the north and south, in honor of the Great Spirit, who could send rain from all parts of the sky. A fifth arrow he retained until it was almost certain that rain was at hand. Then, sending up the shaft from his bow with all his might, to make a hole in the dark cloud over his head, he cried aloud for the waters to pour down at his bidding and to drench him to the skin. He was brandishing his bow in one hand and his medicine in the other, when the rain came down in torrents.'

"Among the Blackfeet Indians, according to W. P. Clark in his 'Indian Sign Language' (Philadelphia, 1885, page 72):—

"'The medicine man has a separate lodge, which faces the east. He fasts and dances to the sun, blowing his whistle. He is painted in different colors, and he must have no water, and only after dark can he eat, and then only the inner bark of the cotton-wood tree. A picture of the sun is painted on his forehead, the moon, ursa major, etc., on his body. The dance continues for four days, and should this medicine man drink it is sure to cause rain, and if it [does not] rains no other evidence of his weakness is wanted or taken. He is deposed as high priest at once.'

"Mr. W. Noble, of Indian Territory, says that 'The Choctaws, during a severe drought, will fasten a fish to one of their number, who then goes into the water and remains there every day for two weeks in order to cause it to rain.' He adds that 'In wet weather, if they wish the rain to cease, they go to a sand bank, put sand in a pan, and dry it over a fire.'

"Among the Moqui, according to Schoolcraft: —

"'There is a charm used for calling down rain. It consists of a small quantity of wild honey wrapped up in the inner fold of the husk of the maize. To produce the effect desired it is necessary to take a piece of the shuck which contained the wild honey, chew it and spit it upon the ground which needs the rain.'*

"Capt. J. G. Bourke, in his 'Snake Dance of the Moqui' (page 120), says:

"'There was painted on the east wall a symbolical design, or "prayer," representing three rows of clouds in red and blue, from which depended long, narrow black and white stripes, typical of rain, while from right and left issued long red and blue snakes, emblematic of lightning. This was a prayer to the god of clouds to send refreshing rains upon the Moqui crops. . . . Yellow was used in all prayers for pumpkins, green for corn, and red for peaches.'

"Among the Zuñi, according to Stevenson, medicine sticks were supposed to influence rain. These little sticks are found hidden beneath the rafters of nearly every house in Zuñi.†

"Passing a little further from home we find, in Acosta's 'History of the Indies,'‡ some accounts of rain producing and weather making among the Peruvian natives. According to him, a Peruvian king in his lifetime caused a figure to be made wherein he was represented, which they called Huaugue, which signifies brother. They carried this image to the wars and in procession for rain or fair weather, making sundry feasts and sacrifices to it. They also pursued other methods. 'In matters of importance they offered up alpacas, hanging the beast by the right fore-leg, turning his eyes to the sun, speaking certain words according to the quality of the sacrifice they slew; for if it were of color their words were addressed to the god of thunder and lightning, that they might want no water' (page 341). If they wanted water, to procure rain they set a black sheep tied in the middle of a plain, pouring much chica about it, and giving it nothing to eat until it rained (page 376). This is practised (says Acosta, 1571–1588), at this day in many places in the month of October.

"What precedes relates to rain making or stopping. A somewhat similar series of facts occur among the American Indians concerning other elements of the weather, but their energies in this direction seem to be expended chiefly in the control of the winds.

"It appears that the Kansas gens of the Omaha are Wind people, and to them is especially entrusted the control of the wind. Mr. J. Owen Dorsey says the Kanze (Kansa or Kaw) gens of the Omaha tribe, being Wind people, 'flap their blankets to start a breeze.' § He adds that when there is a blizzard the other Kansa tribe of Indian Territory beg the members of the Wind gens to interpose, saying, 'O grandfather, I wish good weather. Cause one of your children to be decorated.' Then the youngest son of a

* "History," etc. vol. iii., p. 208.

† 2d Ann. Rep. Bureau of Ethnology, p. 371.

‡ Hakluyt Society edition, Vol. ii., pp. 312, 313.

§ 3d Ann. Rep. Bureau of Ethnology, p. 241.

Kanze man, say one about four feet high, is chosen for the purpose, and painted with red paint. The youth rolls over and over in the snow, reddening it for some distance all around him. This is supposed to stop the blizzard.

"The following account is from a book entitled, 'The Fourteen Ioway Indians' (London, 1844), and relates to raising wind: —

"'A packet ship, with Indians on board, was becalmed for several days near the English coast. It was decided to call upon the medicine man to try the efficacy of his magical powers with the endeavor to raise the wind. After the usual ceremony of a mystery feast, and various invocations to the spirit of the wind and ocean, both were conciliated by the sacrifice of many plugs of tobacco thrown into the sea; and in a little time the wind began to blow, the sails were filled, and the vessel soon wafted into port.'

"The Indians also have many associations with thunder. Madam Lucy Elliot Keeler, in a paper recently contributed to the 'American Agriculturist' for December, 1892, says: —

"'The Dakotas used to have a company of men who claimed the exclusive power and privilege of fighting the thunder. Whenever a storm which they wished to avert threatened, the thunder fighters would take their bows and arrows, their magic drum, and a sort of whistle made of the wing-bone of a war eagle, and, thus armed, run out and fire at the rising cloud, whooping, yelling, whistling, and beating their drum to frighten it down again. One afternoon a heavy black cloud came up, and they repaired to the top of a hill, where they brought all their magic artillery into play against it; but the undaunted thunder darted out a bright flash which struck one of the party dead as he was in the very act of shaking his long-pointed lance against it. After that they decided that no human power could quell the thunder.'

"In the 'Pawnee Hero Stories and Folk-tales,' published by George Bird Grinnell, we find the following: —

"'An old Pawnee Indian said: "Up north, where we worshipped at the time of the first thunder, we never had cyclones. Down here [Indian Territory], now that this worship has been given up, we have them."'

"The Indians in some cases have ideas of controlling the weather more generally, and Dablin, in his 'Relation of the Voyages, Discoveries, and Death of Father James Marquette,' * writing in 1671–1675, says: —

"'It now only remains for me to speak of the calumet, than which there is nothing among the Indians [*i. e.*, the Illinois] more mysterious or more esteemed. . . . They esteem it particularly because they regard it as the calumet of the sun, and, in fact, they present it to him to smoke when they wish to obtain calm or rain or fair weather.'

"Even the control of fog has been attempted, as shown by the following quotation from Dorsey's account of the Turtle subgens of the Omaha: † —

"'In the time of a fog the men of this subgens drew the figure of a turtle on the ground with its face to the south. On the head, tail, middle of

* Hist. Coll. of Louisiana, part iv., 1852, pp. 34, 35.

† 3d Ann. Rep. Bureau of Ethnology, p. 240.

the back and on each leg were placed small pieces of a (red) breech-cloth with some tobacco. This they imagined would make the fog disappear very soon.'

"But it is not only the pagan Indians who have tried their hand at weather-making. Their christianized descendants have also tried to control these operatious of nature. In the transition times between paganism and Christianity occurred some events which throw a curious and instructive side-light on this question, and two of these I will now give.

"Mr. Parkman says that while the Jesuits labored with the Hurons a severe drought came upon the fields. The sorcerers put forth their utmost power, and from the tops of the houses yelled incessant invocations to the spirits. All was in vain. A renowned 'rain-maker,' seeing his reputation tottering under his repeated failures, bethought him of accusing the Jesuits, and gave out that the red color of the cross which stood before their house scared away the bird of thunder and caused him to fly another way. On this a clamor arose. The popular ire turned against the priests, and the obnoxious cross was condemned to be cut down. The Jesuits said: 'If the red color of the cross frightens the bird of thunder, paint it white.' This was done, but the clouds still kept aloof. The Jesuits followed up their advantage. 'Your spirits cannot help you. Now ask the aid of Him who made the world.' Heavy rains occurring soon after, it is said that many Indians believed in the white man's Great Spirit and presented themselves to the priests for baptism (Alice Elliot Keeler).

"A somewhat similar story is told of Peru by Acosta. It appears that the Santa Cruz Indians became Christians because of the success of a renegade soldier in making rain. This soldier, seeing the native Indians 'In a great extremity for water, and that to procure rain they used many superstitious ceremonies, according to their usual manner,' said to them that if they would do as he said they should presently have rain, which they willingly offered to perform. 'Then the soldier made a great cross, which he placed on a high and eminent place, commanding them to worship it and to demand water, which they did. A wonderful thing to see, there presently fell such an abundance of rain, as the Indians took so great devotion to the holy cross as they fled unto it in all their necessities, and obtained all they demanded, so as they broke down their idols.'*

"The quotation from Acosta indicates the attitude of the Indians of middle latitudes on this subject. This attitude, as is well known to those familiar with the Latin-American countries, is preserved unchanged among their descendants. Interesting illustrations of it can be picked up any day even as far north as Arizona and New Mexico, and every traveller in Latin-America has several at his disposal. As the quintessence of them all I present a clipping from the *New York Tribune* to which my attention was called by Dr. T. C. Mendenhall. *Se non è vero è ben trovato.* The extract runs as follows: —

"'In the department of Castañas there had been no rain for nearly a year, and the people were brought to such a pass that they were actually dying of

* Op. cit., vol. ii., p. 524.

thirst, to say nothing of the total destruction of all crops and other agricultural industries.

"'*El Pueblo Católico*, of New San Salvador, prints a number of resolutions promulgated by the principal alcalde of the town and department of Castañas. They are as follows: —

"'Considering that the Supreme Creator has not behaved well in this province, as in the whole of last year only one shower of rain fell; that in this summer, notwithstanding all the processions, prayers, and praises, it has not rained at all, and consequently the crops of Castañas, on which depend the prosperity of the whole department, are entirely ruined, it is decreed: —

"'Article 1. If within the peremptory period of eight days from the date of this decree rain does not fall abundantly, no one will go to mass or say prayers.

"'Article 2. If the drought continues eight days more, the churches and chapels shall be burned, and missals, rosaries, and other objects of devotion will be destroyed.

"'Article 3. If, finally, in a third period of eight days it shall not rain. all the priests, friars, nuns, and saints, male and female, will be beheaded. And for the present permission is given for the commission of all sorts of sin, in order that the Supreme Creator may understand with whom he has to deal.'

"'The most remarkable feature of this affair is the fact that four days after these resolutions were passed the heaviest rainfall known for years was precipitated on the burning community.'"

Ice Needles on Roan Mountain, Tennessee. — Our readers will find in the "Popular Science Monthly," for May, 1894, an interesting article by Mrs. Helen R. Edson on frost formations, photographed by her on the summit of Roan Mountain, Tenn., at an altitude of about 6,400 feet. Lately, this accomplished lady has turned her attention to another form of ice formation, about which we made some remarks in the JOURNAL for April, 1893. The following letter from Mrs. Edson enumerates a number of interesting observations that will contribute to the correct explanation of the method of formation of ice needles. Those interested in the subject should correspond directly with her, in order to concentrate attention upon this interesting and, perhaps, important subject. (C. A.)

(*Extract from letter of* Mrs. H. R. EDSON, *Roan Mountain, Carter Co., Tenn., Oct.* 16, 1894.)

"My study of frost forms was well received generally, and I have not met any one to whom the needle ice does not seem to be also a comparatively unknown branch of science. Roan Mountain offers peculiar advantages for its study. The low latitude and high altitude of its summit, 6,394 feet, furnish in a marked degree the violent alternations of temperature in the spring and fall most favorable to the rapid growth and fine fibre of the needles. They are often finer than the finest cambric needle, 1/40 to 1/50 of an inch in diameter, and resemble closely the fibres of spun glass, or

asbestos. Under the microscope, they appear to be hollow tubes, some hollow throughout, others containing cells of various lengths. After being exposed to the direct rays of the sun at a temperature of 27° Fahr. for several minutes, and then held upright, particles of soil and moisture move slowly down towards the apparent lower ends of the cells and stop, and move back to the other end when reversed.

"I have found large areas of needle-ice 18 inches tall, made in from two to seven successive freezings, one on top of the other, each complete and perfect, and the upper layer supporting great weights, stones, sod, trees, or banks. I could walk on it with my 140 lbs. weight without making any perceptible impression on it, or producing any sound of cracking ice.

"The needles were usually straight; but I sometimes found those nearest a large, flat stone curving over it, with their tops full of pebbles, to be deposited on the stone when the needles melted. It was a question in my mind whether the curvature was caused more by the weight of the pebbles than by the pressure from the crowding needles in the rear. Some of these fagots described a full half circle.

"The most curious bundles of them, curved like rams' horns, I found in a sheltered, roofed spring-house, whose small, narrow door was its only opening. They were on a large, flat rock, which had a thin coating of moss, and lay in the margin of the pool so that the current occasionally washed its edges and kept the moss moistened. One fagot was five inches long and stood three inches tall, holding several heavy pebbles firmly in the end. All the needles in it were continuous from base to tip, following the almost complete whorl. There must have been a gentle breath of air stirring as the vapor rose from the moss, to contribute its aid to the weight of the pebbles, because the latter alone could hardly have caused the upward twist.

"I found the most exquisite specimens in January, on a stick of green firewood stored in a closed room. Compared with the finest made out of doors, it was as fine hair to thread. It was about an inch and a half long, straight and very thickly set on a mossy section. There was a thin line of it along a crevice in the bark.

"There seemed to be a few invariable rules. The more sheltered the location, the more sudden the fall of temperature after a thaw, and the softer and more porous the soil, the more delicate, slender, and tall were the ice columns. Under sheltering banks, a little way down on the leeward side of the mountain, there would be from 1,600 to 2,500 to a square inch, standing 12 to 16 inches tall. The greatest number of layers, or stories, varying in height, were found in shady places to which the sun never penetrates. One layer after another would be formed by the freezing vapor, each in its turn serving as the substratum for those above it, and the upper ones remaining intact, until there were from 2 to 7 strata, each from 1 to 7 inches thick.

"On a coarsely-gravelled roadway, exposed to the sun and wind, I never found them more than 2 inches tall, and from $\frac{1}{8}$ to $\frac{1}{8}$ of an inch in diameter.

"The different layers, or strata, were easily separated entire, and the lower surfaces resembled the sealed lower or upper surface of a honeycomb. The individual needles could be readily detached without injury, but were hard to break transversely.

"The base of each aggregation was exactly level, both the base of the one next the earth, and that of each preceding stratum, so that the lines where they were joined were straight and parallel with the plane of the base, except in the case of curved columns, when the lines of joining radiated from an imaginary centre to the circumference.

"The needles were always perpendicular to the surface to which they clung; no matter what the inclination of the bank, road, or side of a gully, even where the side was vertical, the rule was invariable.

"I am sorry to say this was all I could find out about it, with nothing but a microscope to work with, and I am very anxious to learn more. Now that we have moved down to the 2,650 feet level for the winter, there may be opportunities for more thorough work, though on a smaller scale, this year.

"Can you refer me to authorities on the subject? I find nothing in the encyclopedias, and it is not even named or defined in the dictionaries. And can you give me a few addresses of persons in various localities who would be likely to have observed it closely? A gentleman told me lately that during a trip on the Great Western Plain the earth was parched, and he suffered with thirst. One morning, after a clear, cold night, he found the ground about him covered with needle ice, which he gathered in sufficient quantities to last until he reached a water-supply. I have written to ask him more about the location, character of the soil, time of the year, and size and calibre of the needles.

"Is this a common experience with travellers? It was a beautiful thing to have happen to one."

Equinoctial Storms at Galveston, Texas. — In the Galveston (Texas) *Daily News* for Sept. 23, 1894, is printed an interview with Dr. I. M. Cline, Local Forecast Official of the Weather Bureau, regarding equinoctial storms at Galveston. Dr. Cline says: —

"If people would stop for a moment to consider that the equinoxes are only the intersection of two imaginary lines, the path of the sun and the equator, they would, it seems, conclude without further hesitancy that this could have no absolute effect upon the weather. Some have thought that there is a storm period which recurs about the time of the equinoxes. This feature has been investigated by Mr. R. H. Scott, of London, England. He collected the data relative to storms which occurred in Great Britain for fourteen years, and of eighteen storms which occurred during this time in September; only one occurred on the 21st. Others have studied the question, particularly Prof. H. A. Hazen, of the United States Weather Bureau, who investigated the subject of equinoctial storms in the United States, and reached the following conclusion: 'All the September curves show a tendency to diminished storm action at the time of the equinox. The conclusion is inevitable that the observations do not show a preponderance of storm action at the time of the equinoxes.'

"I have made a brief study of this subject for Galveston through a period of fourteen years, 1880 to 1893, inclusive. The more important features are embraced in the accompanying table, from which it is seen that the wind has attained a velocity of thirty miles or more per hour in only three years out

of the fourteen on September 21. Winds of thirty miles per hour and over average nearly three during the month of September at this station, or one every ten days. In the table I have taken the five days preceding September 21, and the five days following, in all, eleven days, and for these days it is found that only ten days during the fourteen years have had wind of thirty miles per hour or over, while twenty-eight such storms have occurred during the remaining nineteen days of this month during this time. This shows that for the eleven days from September 15 to 26 the liability of the occurrence of a storm is once in eighteen days, while for the remainder of the month they occur once in nine days, or are twice as frequent. The equinoctial season is the one of fewest storms. September is by no means the most windy month of the year at Galveston. Winds above forty miles per hour occur in this month only once in seven years, and are about the same for August and December; they occur once in four years in April and June, once in three years in January, February, March, May, and October, and every other year in November, while in July they occur about once in twenty years. This places September next to the month with the fewest storms.

"I have also noted in the table whether September 21 has been a day with rainfall or a clear day. There is rain at Galveston during September on an average of one day in three. For September 21 the rainfall during the past fourteen years has averaged about one year out of three.

"The foregoing is certainly conclusive evidence that there are no storms at Galveston in September which occur at the proper time with sufficient frequency to justify their being styled equinoctial storms, and in conclusion it can be said we have no equinoctial storms, and fears as to their occurrence should not be entertained."

The weather at Galveston near and at the time of the September equinox: —

Year.	Storms of 30 miles or over in Sept.	Highest wind velocity in 5 days before equinox.	Highest wind velocity on date of equinox.	Highest wind velocity in 5 days after equinox.	Weather.
1880	1	16	16	18	Rain
1881	–	14	9	16	Clear
1882	6	18	25	24	Rain
1883	1	16	32	24	Clear
1884	–	14	9	16	Clear
1885	3	34	20	20	Clear
1886	2	24	24	34	Rain
1887	4	40	36	26	Rain
1888	1	18	18	30	Rain
1889	5	34	12	36	Clear
1890	3	18	12	18	Clear
1891	5	20	40	36	Clear
1892	4	15	14	18	Clear
1893	3	14	13	16	Clear

Royal Meteorological Society.— The opening meeting of the session was held on Wednesday evening, Nov. 21, 1894, at the Institution of Civil Engineers, Westminster, Mr. R. Inwards, F. R. A. S., President, in the chair.

Dr. H. B. Guppy read a paper on suggestions as to the methods of determining the influence of springs on the temperature of a river, as illustrated by the Thames and its tributaries. The methods suggested were: 1. Comparison of the curves of the monthly means of the temperatures of the air and of the water for the river under observation with those of a river beyond the controlling influence of springs. 2. Comparison of the monthly means of the temperature of the river under investigation with that of a river beyond the control of the springs, 3. Comparison of the range of the monthly means of the river temperature with that of the air in the shade. 4. Comparison of the daily range of water temperature at different stations along a river's course. 5. Comparison of sunrise observations made at different stations along a river's course. 6. Comparison of observations made at different stations along a river's course at the hour of maximum temperature. 7. Comparison of the results obtained from a single series of observations made in one day along the whole course of a small tributary like the Wandle or along the upper course of a larger tributary as the Kennet. 8. Determination of the distance from its sources at which the river begins to freeze.

Mr. Eric S. Bruce, F. R. Met. Soc., exhibited and described some lantern slides showing the disastrous effects of the great gale of Nov. 17 and 18, 1893, upon trees in Perthshire, Scotland.

Mr. Alfred B. Wollaston gave an account of the formation of some waterspouts which he had observed in the Bay of Bengal.

Remarkable Hail.— In the *Monthly Weather Review* for May, 1894, page 215, there is a note regarding some remarkable hail-stones which fell near Vicksburg, Miss., on May 11. One remarkably large hailstone was found to have a solid nucleus consisting of a piece of alabaster from one half to three quarters of an inch, and in the same storm a gopher turtle, 6 by 8 inches, entirely encased in ice, fell with the hail. Concerning these occurrences, Prof. Abbe remarks: "The fact that hailstones, as well as drops of water and flakes of snow, often contain nuclei that must have been carried up from the earth's surface, is entirely in accord with the general principle that ascending currents precede the formation of cloud and rain, and that solid nuclei are needed to initiate the ordinary precipitation of moisture."

Sunspots, Weather and Climatic Changes in Aix-la-Chappelle. — In the April and August numbers of *Das Wetter*, Dr. Polis had papers on the "Relation of Sunspots, Weather and Climatic Changes in Aix-la-Chappelle." From a study of the temperature records, 1829–1893, he concludes (1) that at a time of sunspot minima warm autumns and warm springs prevail, and these precede the times of sunspot minima by about two years, on the average; (2) that at the time of sunspot maxima there is usually a low-

ering of the spring and fall temperatures. What is true of the mean spring and autumn temperatures is also true of the mean winter and summer temperatures; therefore, there does seem to be a relation between the number of sunspots and the mean yearly and seasonal temperatures, but this influence is secondary. Further, the main climatic changes of temperature are produced independently of the number of sunspots, but the number of spots has a secondary effect in strengthening or weakening the temperature curve.

A Long-Period Meteorograph. — M. Jules Richard, of the well-known firm of instrument makers in Paris, has constructed for Dr. Janssen, for use at the Mont Blanc Observatory, a meteorograph which will run eight months without re-winding. The instrument, kept in motion by a weight of ninety kilograms, which falls from five to six meters in eight months, registers pressure, temperature, wind direction and velocity, and humidity. An account of the meteorograph, with illustrations, may be found in *Nature* for October 25, 1894 (Vol. 50, No. 1304).

Weather Bureau Notes. — A Section of Sanitary Climatology has been added to the sub-divisions of the Weather Bureau. The work of this section will relate to the aspects of climate of especial interest to the medical and sanitary professions.

The Civil Service Commission held a competitive examination on Oct. 22, 1894, for a physician to be placed in charge of this section. The successful candidate was Dr. W. F. R. Phillips, of the Bureau.

Errata in "The Meteorological Services of South America. II."

Page 201, line 12 from top, for "Conception" *read* "Concepcion."
Page 202, line 21 from top, for "Anuales" *read* "Anales."
Page 206, line 13 from top, for "Annuario" *read* "Anuario."
Page 210, bottom line, for "now" *read* "were."
Page 211, top line, for "Boletin" *read* "Boletins."
Page 211, line 3 from top, for "Capauema" *read* "Capanema."
Page 211, line 12 from top, for "Boletin" *read* "Boletim."

TITLES OF RECENT PUBLICATIONS

FURNISHED BY MR. OLIVER L. FASSIG, LIBRARIAN, U. S. WEATHER BUREAU, WASHINGTON, D. C.

(An asterisk [*] indicates that the publications thus designated have been received by the Editor of this JOURNAL.)

* BLUE HILL METEOROLOGICAL OBSERVATORY. *Observations made in the year 1893, under the direction of A. Lawrence Rotch. With appendices containing studies of the short, wave-like oscillations and of the average weather conditions in a period of 26.68 days.* Annals of the Astronomical Observatory of Harvard College. Vol. xl. Part III. pp. 143–205. 3 pls. 4to. Cambridge, 1894.

CEYLON, ACTING SURVEYOR-GENERAL. *Report on the Meteorology of Ceylon for 1893.* 35 pp. 1 table. 2 pls.

COLLINSON, JOHN. *Rainmaking and sunshine.* London, 1894.

CORNWALL POLYTECHNIC SOCIETY. *The sixtieth annual report of the Royal Cornwall Polytechnic Society.* 1892. 8vo. Falmouth, 1894. (Contains meteorological tables for Falmouth and the Scilly Islands, and tables of magnetic declination, inclination, and intensity at Falmouth Observatory for 1892.)

GREELY, A. W. *Climatic conditions of Nicaragua, with special reference to military operations on land.* Appendix I. to "The Nicaragua Canal in its military aspects," by Capt. George P. Scriven. Senate, Executive Document, No. 74 53d Congress, 2d Session. 8vo. Wash., 1894. pp. 48–55.

INTERNATIONAL METEOROLOGICAL COMMITTEE. *Procès-Verbeaux de la première réunion tenue à Upsal, en Aout* 1894. 8vo. (Paris, 1894.) 11 pp. (Proof, subject to correction.)

KAMMERMANN, A. *Résumé météorologique de l'année* 1893 *pour Genève et le Grand Saint-Bernard.* 8vo. Genève, 1894. (Extracted from Archives des sciences de la Bibliothéque Universelle, Oct. et Nov., 1894.) 8vo. Genève, 1894. 148 pp.

* KING, F. H. *Destructive effects of winds on sandy soils and light sandy loams, with methods of prevention.* Wisconsin Agric. Exp. Sta., Bull. No. 48. 8vo. Madison, 1894. 29 pp.

MAGDEBURG. WETTERWARTE DER MADGEBURGISCHEN ZEITUNG. *Jahrbuch der meteorologischen Beobachtungen.* Band XI. Jahrg. XII. 1892. 4to. Magdeburg, 1893. 54 pp.

* NEW ENGLAND WEATHER SERVICE. *Observations in the year* 1892. Annals of the Harvard College Observatory. Cambridge. Vol. xli. No. 1. 1894. 31 pp. 1 pl.

OLSSON, DR. K. G. *On the calculation of photographic cloud measurements.* (From the Quarterly Journal of the Royal Meteorological Society, Vol. XX., No. 91, July, 1894, pp. 187–198.)

PRUSSIA. KOEN. PREUSS. METEOROL. INSTITUT. *Ergebnisse der magnetischen Beobachtungen in Potsdam in den Jahren* 1890 *und* 1891. 4to. Berlin, 1894. XLIV., 84 pp. 10 pl. (First of the series of observations to be issued annually from the Potsdam Magnetic Observatory. Contains a detailed description of the instruments and methods employed and hourly values for the declination, horizontal-intensity and vertical-intensity in the years 1890 and 1891.)

* PRUSSIA. *Jahresbericht ueber die Beobachtungsergebnisse der von den forstlichen Versuchsanstalten des Koenigreichs Preussen, des Herzogthums Braunschweig, der Reichslande und dem Landesdirectorium der Provinz Hannover eingerichteten forstlich-meteorologischen Stationen.* Hrsg. von Dr. A. Muettrich. 19 Jahrg., 1893. 8vo. Berlin, 1894. 119 pp.

U. S. COAST AND GEODETIC SURVEY. *Results of magnetic observations at stations in Alaska and in the Northwest Territory of the Dominion of Canada.* (Observations in Alaska in 1889, 1890, and 1891.) In Report U. S. Coast and Geodetic Survey, Washington, 1892, part 2, appendix No. II., pp. 529–533.

U. S. COAST AND GEODETIC SURVEY. *Results of the observations recorded at the U. S. Coast and Geodetic Survey Magnetic Observatory at Los Angeles, Cal., between* 1882 *and* 1889. Part IV. *Results of the differential measure of the vertical force component, and of the variations of dip, and total force.* Discussion and report by Charles A. Schott. In Report U. S. Coast and Geodetic Survey, Washington, 1892. Part 2. Appendix No. 7. pp. 253–327. 2 pl.

U. S. HYDROGRAPHIC OFFICE. *No.* 109. *Coutributions to terrestrial magnetism. The variation of the compass. From observations made in the U. S. Naval Service during the period from* 1881 *to* 1894. 8vo. Washington, 1894. 50 pp.

* U. S. WEATHER BUREAU. Circular F, Instrument Room. *Barometers and the measurement of atmospheric pressnre. A pamphlet of information respecting the theory and construction of barometers in general, with summary of instructions for the care and use of the standard Weather Bureau instruments.* Prepared by Prof. C. F. Marvin. 8vo. Washington, 1894. 74 pp.

WASHBURN OBSERVATORY. PUBLICATIONS OF THE WASHBURN OBSERVATORY OF THE UNIVERSITY OF WISCONSIN. *Vol. VII. Part 2. Meteorological Observations,* 1890-91-92-93. 4to. Madison, 1894. pp. 91–195. (Daily observations in extenso at 7 A. M., 2 and 9 P. M.)